

CLAIMS

1. A first-order modified, hydrogenated polymer comprising:

5 (1) a hydrogenated polymer obtained by hydrogenating at least one unhydrogenated polymer selected from the group consisting of (1-A) a polymer comprising conjugated diene monomer units and (1-B) a copolymer comprising conjugated diene monomer units and vinyl aromatic hydrocarbon monomer units, said copolymer (1-B) having no or at least one polymer block (H) of said vinyl aromatic hydrocarbon monomer units, and

10 (2) a functional group-containing first-order modifier group bonded to said hydrogenated polymer (1), wherein said functional group-containing first-order modifier group comprises at least one functional group selected from the group consisting of a hydroxyl group, an epoxy group, an amino group, a silanol group and an alkoxy silane group,

15 said first-order modified, hydrogenated polymer having the following characteristics (i) to (iv):

(i) a content of said vinyl aromatic hydrocarbon monomer units of from 0 to 60 % by weight, based on the weight of said hydrogenated polymer,

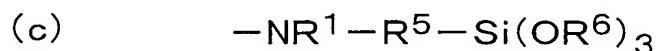
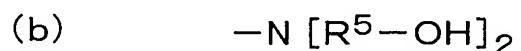
20 (ii) a vinyl aromatic hydrocarbon block ratio of

from 0 to less than 50 % by weight, wherein said vinyl aromatic hydrocarbon block ratio is defined as the percent by weight of the vinyl aromatic hydrocarbon monomer units contained in said at least one polymer block (H) of said vinyl aromatic hydrocarbon monomer units, based on the total weight of vinyl aromatic hydrocarbon monomer units contained in said copolymer (1-B),

5 (iii) a weight average molecular weight of from 20,000 to 2,000,000, and

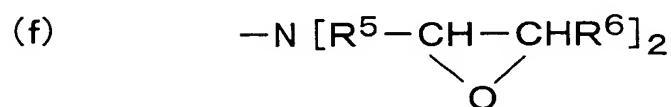
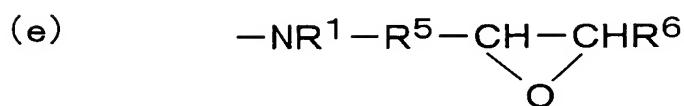
10 (iv) a hydrogenation ratio of more than 70 %, as measured with respect to the double bonds in said conjugated diene monomer units.

2. The first-order modified, hydrogenated polymer according to claim 1, wherein said functional group-containing first-order modifier group (2) comprises at least one functional group represented by a formula selected from the group consisting of the following formulae (a) to (m):

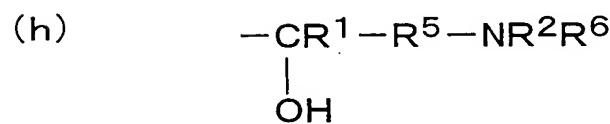
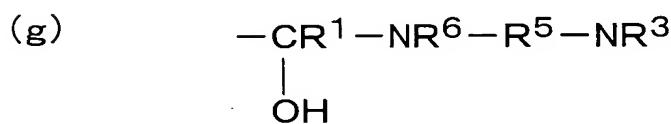




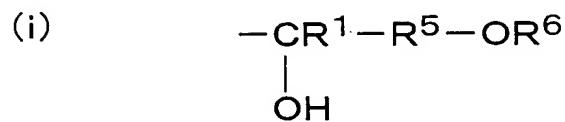
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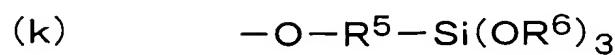
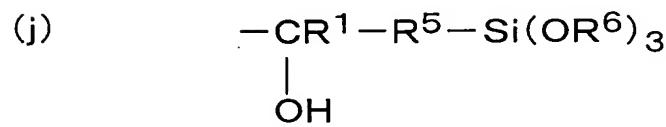
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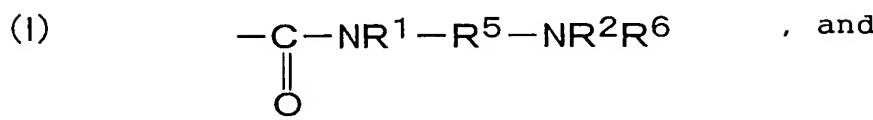
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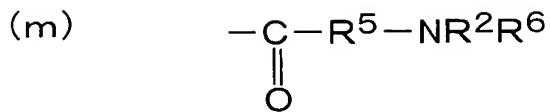


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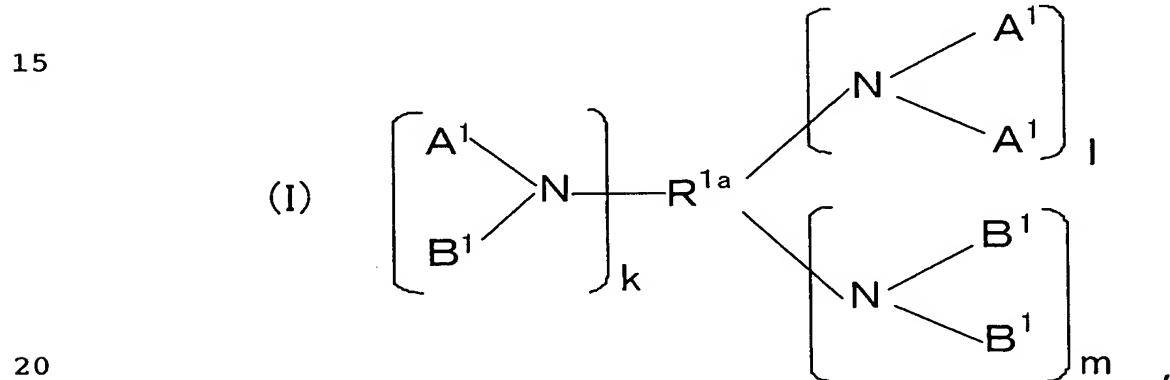


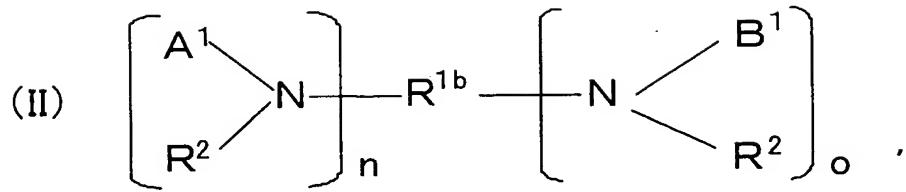
wherein, in the formulae (a) to (m):

- 5 N represents a nitrogen atom, Si represents a silicon atom, O represents an oxygen atom, C represents a carbon atom, and H represents a hydrogen atom,
- 10 each of R¹ to R⁴ independently represents a hydrogen atom or a C₁-C₂₄ hydrocarbon group which optionally has at least one functional group selected from the group consisting of a hydroxyl group, an epoxy group, an amino group, a silanol group and a C₁-C₂₄ alkoxy silane group,
- 15 each R⁵ independently represents a C₁-C₄₈ hydrocarbon group and optionally, independently has at least one functional group selected from the group consisting of a hydroxyl group, an epoxy group, an amino group, a silanol group and a C₁-C₂₄ alkoxy silane group,
- 20 each R⁶ independently represents a hydrogen atom or a C₁-C₈ alkyl group,
- 25 wherein each of R¹ to R⁵ optionally, in-

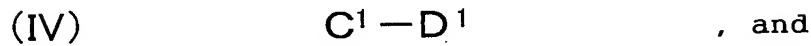
dependently has bonded thereto at least one atom selected from the group consisting of an oxygen atom, a nitrogen atom, a sulfur atom and a silicon atom, said at least one atom being present in a linkage other than a hydroxyl group, an epoxy group, an amino group, a silanol group and an alkoxy silane group.

3. The first-order modified, hydrogenated polymer according to claim 1 or 2, which is represented by a formula selected from the group consisting of the following formulae (I) to (V):





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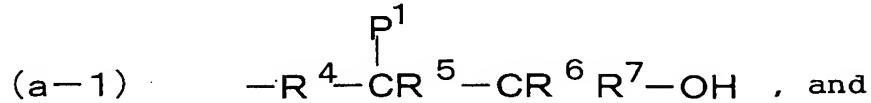
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wherein:

A^1 represents a unit which is represented by any one of the following formulae (a-1) and (b-1):

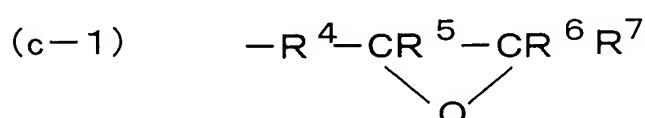
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B^1 represents a unit which is represented by the following formula (c-1):

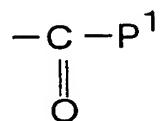
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C^1 represents a unit which is represented by any one of the following formulae (d-1) and (e-1):

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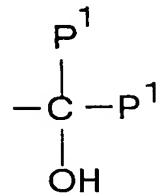
(d-1)



, and

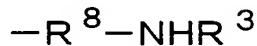
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(e-1)



D^1 represents a unit which is represented by the following formula (f-1):

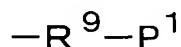
(f-1)



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E^1 represents a unit which is represented by the following formula (g-1):

(g-1)

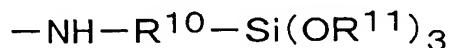


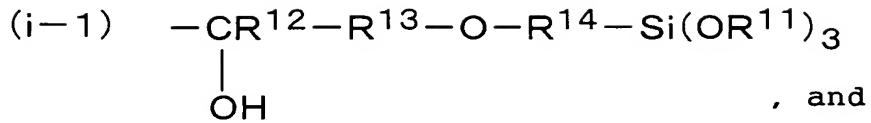
, and

F^1 represents a unit which is represented by any one of the following formulae (h-1) to (j-1):

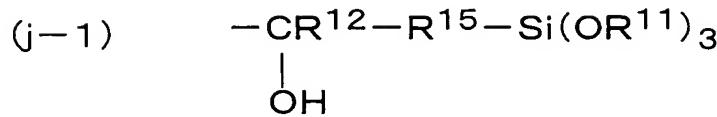
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(h-1)





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wherein, in the formulae (I) to (III) and
 (a-1) to (j-1):

10

N represents a nitrogen atom, Si
 represents a silicon atom, O represents
 an oxygen atom, C represents a carbon
 atom, and H represents a hydrogen atom,
 p¹ represents said hydrogenated polymer
 (1),

15

R^{1a} represents a trivalent aliphatic
 C₁-C₄₈ hydrocarbon group,
 each of R^{1b}, R⁴, R⁸ to R¹⁰ and R¹³ to R¹⁵
 independently represents a C₁-C₄₈ alkylene
 group,

20

each of R², R³ and R¹¹ independently
 represents a C₁-C₄₈ alkyl group, a C₆-C₄₈
 aryl group, an alkylaryl group comprised
 of C₁-C₄₈ alkyl and C₆-C₄₈ aryl, an aralkyl
 group comprised of C₁-C₄₈ alkyl and C₆-C₄₈
 aryl, or a C₃-C₄₈ cycloalkyl group,

25

wherein each of R^{1a}, R^{1b}, R³, R⁴, R⁸ to
R¹⁰ and R¹³ to R¹⁵ optionally, independently
has at least one functional group selected
from the group consisting of a hydroxyl
group, an epoxy group, an amino group, a
silanol group and a C₁-C₂₄ alkoxy silane
group,

5

each of R⁵ to R⁷ and R¹² independently
represents a hydrogen atom, a C₁-C₄₈ alkyl
group, a C₆-C₄₈ aryl group, an alkyl aryl
group comprised of C₁-C₄₈ alkyl and C₆-C₄₈
aryl, an aralkyl group comprised of C₁-C₄₈
alkyl and C₆-C₄₈ aryl, or a C₃-C₄₈ cyclo-
alkyl group,

10

15

wherein each of R^{1a}, R^{1b}, R² to R⁴ and R⁸
to R¹⁵ optionally, independently has
bonded thereto at least one atom selected
from the group consisting of an oxygen
atom, a nitrogen atom, a sulfur atom and
a silicon atom, said at least one atom
being present in a linkage other than a
hydroxyl group, an epoxy group, an amino
group, a silanol group and an alkoxy si-
lane group, and

20

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each of k, l, m and o is independently

an integer of 0 or more, provided that
both k and l are not simultaneously 0,
and n is an integer of 1 or more.

5 4. A filler-containing modified polymer composition
comprising:

100 parts by weight of (A-1) the first-order modified,
hydrogenated polymer of any one of claims 1 to 3,
and

10 0.5 to 300 parts by weight of (B) a reinforcing
filler.

15 5. The filler-containing modified polymer composition
according to claim 4, which further comprises 0.01 to
20 parts by weight of (C) a second-order modifier hav-
ing a functional group which is reactive to said func-
tional group of said modifier group of said first-order
modified, hydrogenated polymer (A-1), wherein said sec-
ond-order modifier (C) is at least one member selected
20 from the group consisting of a functional monomer and a
functional oligomer.

25 6. The filler-containing modified polymer composition
according to claim 4 or 5, wherein said reinforcing
filler (B) is at least one member selected from the

group consisting of a silica inorganic filler, a metal oxide, a metal hydroxide and carbon.

7. A crosslinked, filler-containing modified polymer composition obtained by subjecting the filler-containing modified polymer composition of any one of claims 4 to 6 to a crosslinking reaction in the presence of a vulcanizing agent.

10 8. A modified polymer composition comprising:
1 to 99 parts by weight, relative to 100 parts by weight of the total of components (A-1) and (D), of (A-1) the first-order modified, hydrogenated polymer of any one of claims 1 to 3, and
15 99 to 1 part by weight, relative to 100 parts by weight of the total of components (A-1) and (D), of (D) at least one polymer selected from the group consisting of a thermoplastic resin other than said first-order modified, hydrogenated polymer (A-1) and a rubbery polymer other than said first-order modified, hydrogenated polymer (A-1).

20 9. The modified polymer composition according to claim 8, which further comprises 0.01 to 20 parts by weight, relative to 100 parts by weight of the total of

components (A-1) and (D), of (C) a second-order modifier having a functional group which is reactive to said functional group of said modifier group of said first-order modified, hydrogenated polymer (A-1),

5 wherein said second-order modifier (C) is at least one member selected from the group consisting of a functional monomer and a functional oligomer.

10. The modified polymer composition according to
claim 8 or 9, wherein said rubbery polymer in component
(D) comprises at least one member selected from the
group consisting of a conjugated diene polymer compris-
ing conjugated diene monomer units, a random copolymer
comprising conjugated diene monomer units and vinyl
aromatic hydrocarbon monomer units, a block copolymer
15 comprising conjugated diene monomer units and vinyl
aromatic hydrocarbon monomer units, a non-diene polymer
and a natural rubber,

20 said rubbery polymer being unhydrogenated or at
least partially hydrogenated.

11. The modified polymer composition according to any
one of claims 8 to 10, wherein said thermoplastic resin
in component (D) is a functional group-containing ther-
25 moplastic resin and said rubbery polymer in component

(D) is a functional group-containing rubbery polymer,
wherein each of said functional group-containing ther-
moplastic resin and rubbery polymer contains at least
one functional group which is reactive to said func-
tional group of said first-order modifier group of said
first-order modified, hydrogenated polymer (A-1).

12. The modified polymer composition according to
claim 11, wherein said functional group-containing
thermoplastic resin comprises at least one member se-
lected from the group consisting of a polyester resin,
a polyamide resin, a polycarbonate resin, a polyure-
thane resin, a polyphenylene ether resin and a polyoxy-
ethylene resin each of which contains at least one
functional group selected from the group consisting of
an acid anhydride group, a carboxyl group, a hydroxyl
group, an epoxy group, an amino group, a silanol group
and an alkoxy silane group.

13. An adhesive composition comprising:
100 parts by weight of (A-1) the first-order modi-
fied, hydrogenated polymer of any one of claims 1 to 3,
and
20 to 400 parts by weight of (E) a tackifier.

14. The adhesive composition according to claim 13,
which further comprises 0.01 to 20 parts by weight of
(C) a second-order modifier having a functional group
which is reactive to said functional group of said
5 modifier group of said first-order modified, hydrogen-
ated polymer (A-1), wherein said second-order modifier
(C) is at least one member selected from the group con-
sisting of a functional monomer and a functional oli-
gomer.

10

15. An asphalt composition comprising:
0.5 to 50 parts by weight of (A-1) the first-order
modified, hydrogenated polymer of any one of claims 1
to 3, and
15 100 parts by weight of (F) an asphalt.

16. The asphalt composition according to claim 15,
which further comprises 0.01 to 20 parts by weight of
(C) a second-order modifier having a functional group
20 which is reactive to said functional group of said
modifier group of said first-order modified, hydrogen-
ated polymer (A-1), wherein said second-order modifier
(C) is at least one member selected from the group con-
sisting of a functional monomer and a functional oli-
25 gomer.

17. A styrene resin composition obtained by subjecting a raw material mixture to radical polymerization, said raw material mixture comprising:

5 2 to 30 parts by weight, relative to 100 parts by weight of the total of components (A-1) and (G), of (A-1) the first-order modified, hydrogenated polymer of any one of claims 1 to 3, and

10 98 to 70 parts by weight, relative to 100 parts by weight of the total of components (A-1) and (G), of (G) a vinyl aromatic hydrocarbon monomer or a mixture of a vinyl aromatic hydrocarbon monomer and a comonomer copolymerizable with said vinyl aromatic hydrocarbon monomer.

15

18. The styrene resin composition according to claim 17, wherein said raw material mixture further comprises 0.01 to 20 parts by weight, relative to 100 parts by weight of the total of components (A-1) and (G), of (C) 20 a second-order modifier having a functional group which is reactive to said functional group of said modifier group of said first-order modified, hydrogenated polymer (A-1), wherein said second-order modifier (C) is at least one member selected from the group consisting of 25 a functional monomer and a functional oligomer.

19. A method for producing the styrene resin composition of claim 17 or 18, comprising:

(1) providing a raw material mixture comprising
5 (A-1) the first-order modified, hydrogenated polymer of any one of claims 1 to 3, (G) a vinyl aromatic hydrocarbon monomer or a mixture of a vinyl aromatic hydrocarbon monomer and a comonomer copolymerizable with said vinyl aromatic hydrocarbon monomer, and optionally
10 at least one member selected from the group consisting of (C) a second-order modifier and (B) a reinforcing filler, and

(2) subjecting said raw material mixture to radical polymerization,

15 thereby obtaining a styrene resin composition.

20. A second-order modified polymer comprising:

(β) a base polymer, and
20 (δ) a functional group-containing modifier group bonded to said base polymer (β),
wherein said second-order modified polymer is obtained by reacting a second-order modifier with a first-order modified polymer comprising (β) a base polymer and (γ) a functional group-containing first-order modifier group bonded to said base polymer (β) to

thereby form (δ) a functional group-containing modifier group, wherein said second-order modifier has a functional group which is reactive to said functional group of said first-order modifier group (γ) of said first-order modified polymer, and wherein said second-order modifier is used in an amount of 0.3 to 10 moles, relative to one equivalent of the functional group of said first-order modifier group (γ) of said first-order modified polymer,

10 said second-order modifier being at least one member selected from the group consisting of a functional monomer and a functional oligomer,

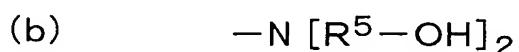
15 wherein said base polymer (β) of said first-order modified polymer is unhydrogenated or at least partially hydrogenated and is at least one member selected from the group consisting of the following polymers (β -1) to (β -3):

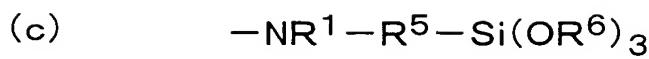
(β -1) a conjugated diene polymer comprising conjugated diene monomer units,

20 (β -2) a copolymer comprising conjugated diene monomer units and vinyl aromatic hydrocarbon monomer units, said copolymer having no or at least one polymer block (H) of said vinyl aromatic hydrocarbon monomer units, wherein said copolymer has a vinyl

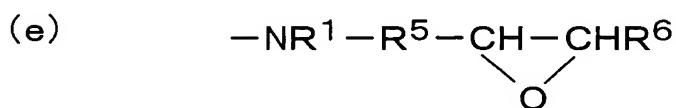
aromatic hydrocarbon block ratio of from 0
to less than 50 % by weight, said vinyl aro-
matic hydrocarbon block ratio being defined
as the percent by weight of the vinyl aro-
matic hydrocarbon monomer units contained in
5 said at least one polymer block (H) of said
vinyl aromatic hydrocarbon monomer units,
based on the total weight of vinyl aromatic
hydrocarbon monomer units contained in said
copolymer as in the unhydrogenated state,
10 and

(β-3) a vinyl aromatic hydrocarbon poly-
mer comprising vinyl aromatic hydrocarbon
monomer units, and
15 wherein said functional group-containing
first-order modifier group (γ) of said first-order
modified polymer comprises at least one functional
group represented by a formula selected from the
group consisting of the following formulae (a) to
20 (m):

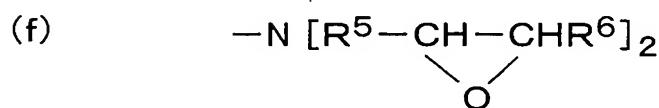




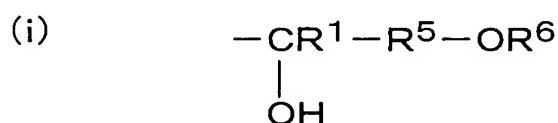
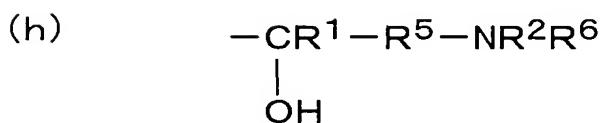
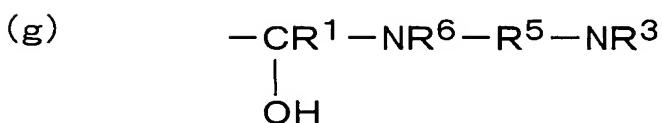
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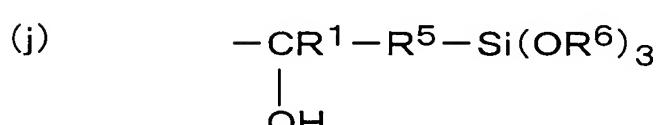
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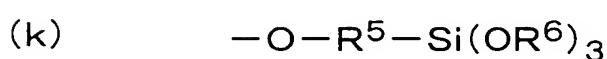
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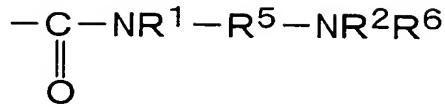
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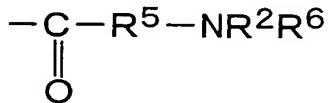


(I)



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(m)



wherein, in the formulae (a) to (m):

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N represents a nitrogen atom, Si represents a silicon atom, O represents an oxygen atom, C represents a carbon atom, and H represents a hydrogen atom,

15

each of R¹ to R⁴ independently represents a hydrogen atom or a C₁-C₂₄ hydrocarbon group which optionally has at least one functional group selected from the group consisting of a hydroxyl group, an epoxy group, an amino group, a silanol group and a C₁-C₂₄ alkoxy silane group,

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each R⁵ independently represents a C₁-C₄₈ hydrocarbon group and optionally, independently has at least one functional group selected from the group consisting of a hydroxyl group, an epoxy group, an amino group, a silanol group and a C₁-C₂₄ alkoxy silane group,

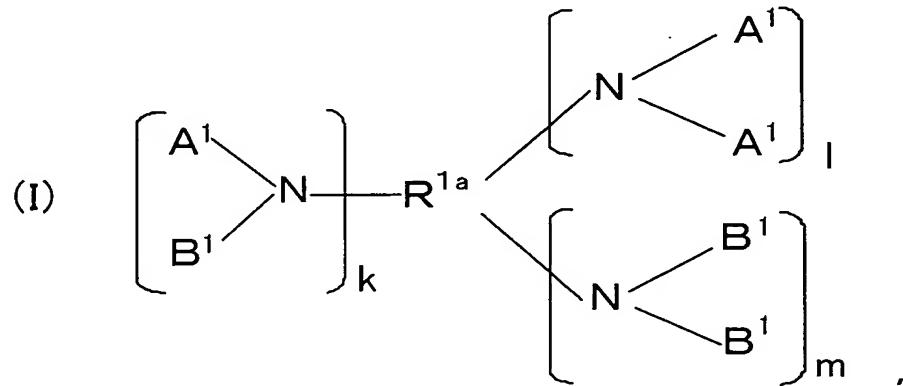
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each R⁶ independently represents a hydrogen atom or a C₁-C₈ alkyl group,
wherein each of R¹ to R⁵ optionally, independently has bonded thereto at least
5 one atom selected from the group consisting of an oxygen atom, a nitrogen atom, a sulfur atom and a silicon atom, said at least one atom being present in a linkage other than a hydroxyl group, an epoxy group, an amino group, a silanol group and
10 an alkoxy silane group.

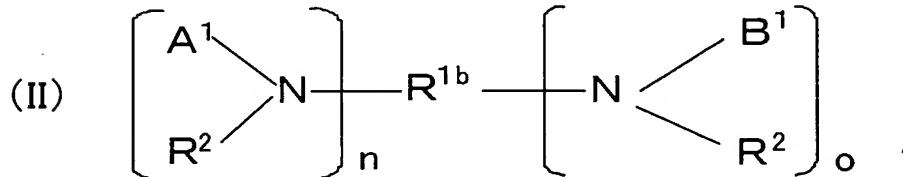
21. The second-order modified polymer according to claim 20, wherein said first-order modified polymer is represented by a formula selected from the group consisting of the following formulae (I) to (V):

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(III)



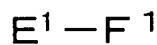
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(IV)



, and

(V)



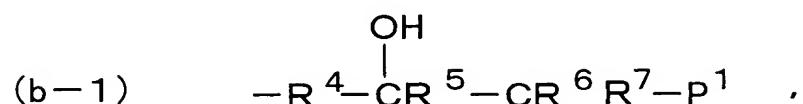
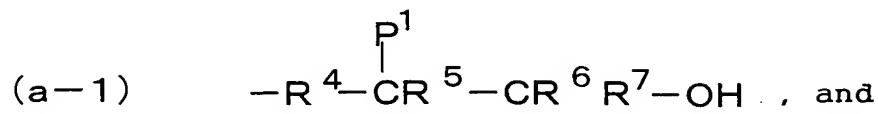
wherein:

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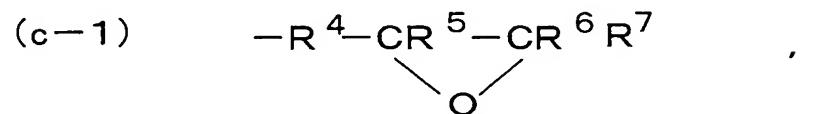
A^1 represents a unit which is represented by any

one of the following formulae (a-1) and (b-1):

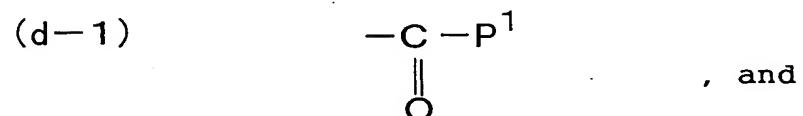
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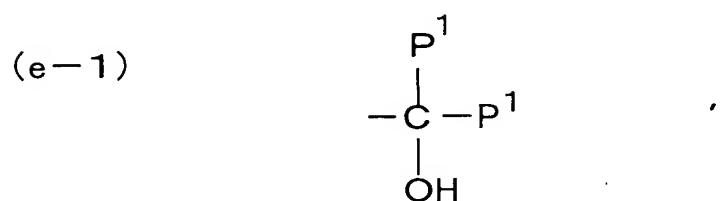
B^1 represents a unit which is represented by the
10 following formula (c-1):



C^1 represents a unit which is represented by any
15 one of the following formulae (d-1) and (e-1):



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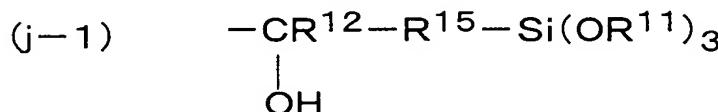
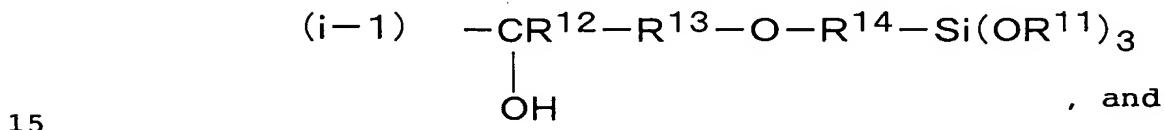
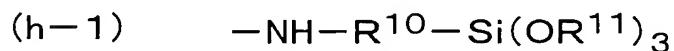
D^1 represents a unit which is represented by the
25 following formula (f-1):



5 E^1 represents a unit which is represented by the
following formula (g-1):



10 F^1 represents a unit which is represented by any
one of the following formulae (h-1) to (j-1):



20 wherein, in the formulae (I) to (III) and
(a-1) to (j-1):

N represents a nitrogen atom, Si
represents a silicon atom, O represents
an oxygen atom, C represents a carbon
atom, and H represents a hydrogen atom,

P¹ represents said base polymer,
R^{1a} represents a trivalent aliphatic
C₁-C₄₈ hydrocarbon group,
each of R^{1b}, R⁴, R⁸ to R¹⁰ and R¹³ to R¹⁵
5 independently represents a C₁-C₄₈
alkylene group,
each of R², R³ and R¹¹ independently
represents a C₁-C₄₈ alkyl group, a C₆-C₄₈
aryl group, an alkylaryl group comprised
10 of C₁-C₄₈ alkyl and C₆-C₄₈ aryl, an
aralkyl group comprised of C₁-C₄₈ alkyl
and C₆-C₄₈ aryl, or a C₃-C₄₈ cycloalkyl
group,
wherein each of R^{1a}, R^{1b}, R³, R⁴, R⁸ to
15 R¹⁰ and R¹³ to R¹⁵ optionally, independ-
ently has at least one functional group
selected from the group consisting of a
hydroxyl group, an epoxy group, an amino
group, a silanol group and a C₁-C₂₄
20 alkoxysilane group,
each of R⁵ to R⁷ and R¹² independently
represents a hydrogen atom, a C₁-C₄₈
alkyl group, a C₆-C₄₈ aryl group, an
alkylaryl group comprised of C₁-C₄₈ alkyl
25 and C₆-C₄₈ aryl, an aralkyl group com-

prised of C₁-C₄₈ alkyl and C₆-C₄₈ aryl, or
a C₃-C₄₈ cycloalkyl group,

wherein each of R^{1a}, R^{1b}, R² to R⁴ and
R⁸ to R¹⁵ optionally, independently has
bonded thereto at least one atom se-
lected from the group consisting of an
oxygen atom, a nitrogen atom, a sulfur
atom and a silicon atom, said at least
one atom being present in a linkage
other than a hydroxyl group, an epoxy
group, an amino group, a silanol group
and an alkoxy silane group, and
each of k, l, m and o is independ-
ently an integer of 0 or more, provided
that both k and l are not simultaneously
0, and n is an integer of 1 or more.

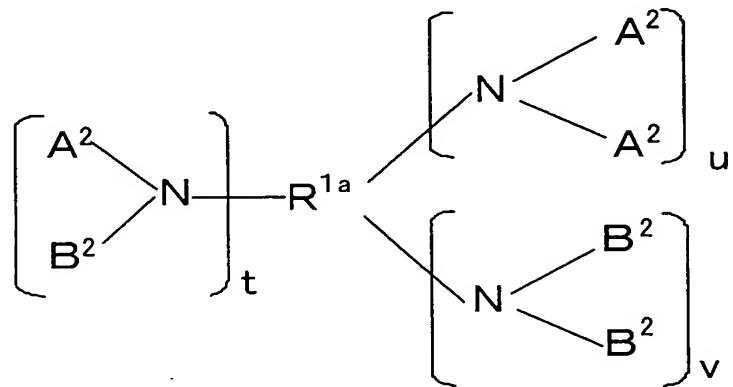
22. The second-order modified polymer according to
claim 20 or 21, wherein each of said functional monomer
and said functional oligomer has at least one func-
tional group selected from the group consisting of a
hydroxyl group, an amino group, a carboxyl group, an
acid anhydride group, an isocyanate group, an epoxy
group, a silanol group and an alkoxy silane group.

23. The second-order modified polymer according to any one of claims 20 to 22, which is represented by a formula selected from the group consisting of the following formulae (VI) to (X):

5

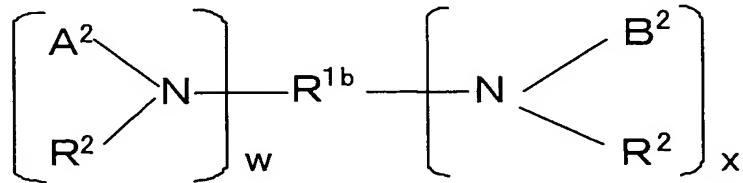
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(VI)



15

(VII)



20

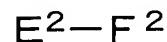
(VIII)



(IX)



(X)

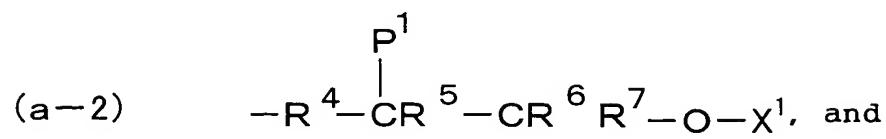


25

wherein:

A^2 represents a unit which is represented by any one of the following formulae (a-2) and (b-2):

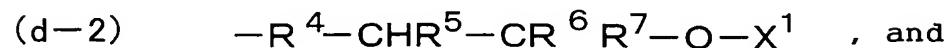
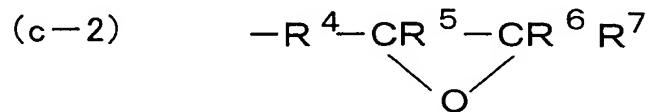
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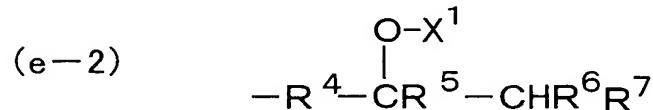
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B^2 represents a unit which is represented by any one of the following formulae (c-2) to (e-2):

15



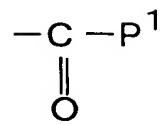
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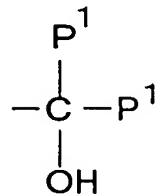
C^2 represents a unit which is represented by any one of the following formulae (f-2) to (h-2):

(f-2)



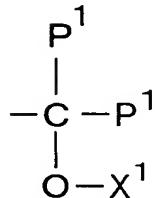
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(g-2)



10

(h-2)



D^2 represents a unit which is represented by the following formula (i-2):

15

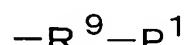
(i-2)



E^2 represents a unit which is represented by the following formula (j-2):

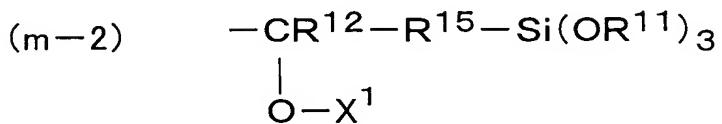
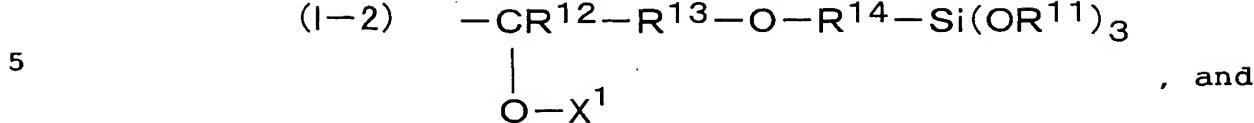
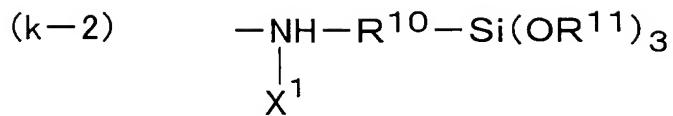
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(j-2)



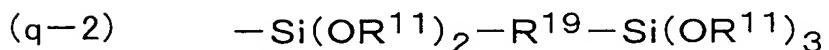
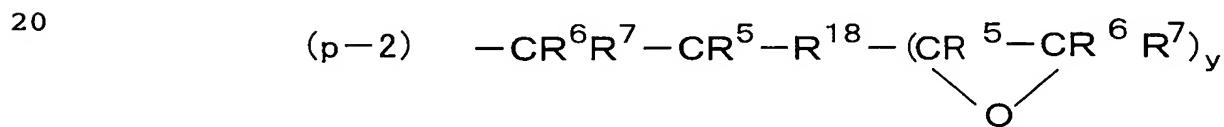
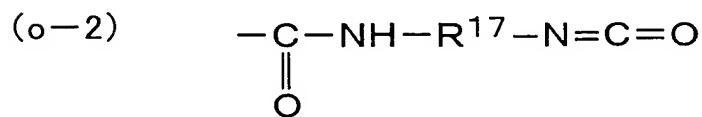
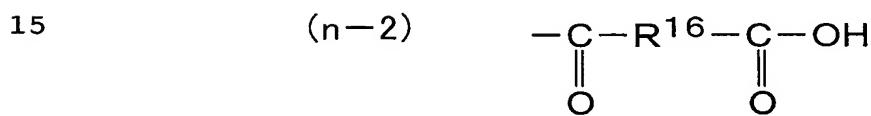
, and

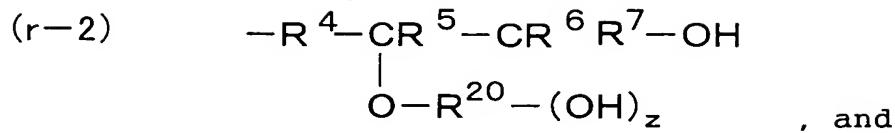
F^2 represents a unit which is represented by any one of the following formulae (k-2) to (m-2):



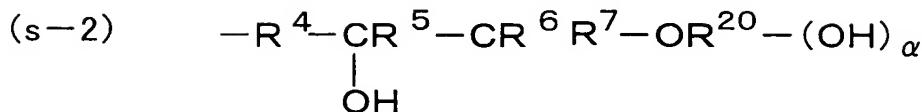
wherein:

X^1 represents a unit which is represented by any one of the following formulae (n-2) to (s-2):





5



wherein, in the formulae (VI) to (VIII)
10 and (a-2) to (s-2):

N represents a nitrogen atom, Si represents a silicon atom, O represents an oxygen atom, C represents a carbon atom, and H represents a hydrogen atom,

15 P¹ represents the base polymer,

R^{1a} represents a trivalent aliphatic C₁-C₄₈ hydrocarbon group,

each of R^{1b}, R⁴, R⁸ to R¹⁰ and R¹³ to R²⁰ independently represents a C₁-C₄₈ alkylene group,

20 each of R², R³ and R¹¹ independently represents a C₁-C₄₈ alkyl group, a C₆-C₄₈ aryl group, an alkylaryl group comprised of C₁-C₄₈ alkyl and C₆-C₄₈ aryl, an aralkyl group comprised of C₁-C₄₈ alkyl and C₆-C₄₈

aryl, or a C₃-C₄₈ cycloalkyl group,

wherein each of R^{1a}, R^{1b}, R³, R⁴, R⁸ to R¹⁰, R¹³ to R¹⁵ and R¹⁷ to R²⁰ optionally, independently has at least one functional group selected from the group consisting of a hydroxyl group, an epoxy group, an amino group, a silanol group and a C₁-C₂₄ alkoxy silane group,

5

each of R⁵ to R⁷ and R¹² independently represents a hydrogen atom, a C₁-C₄₈ alkyl group, a C₆-C₄₈ aryl group, an alkyl aryl group comprised of C₁-C₄₈ alkyl and C₆-C₄₈ aryl, an aralkyl group comprised of C₁-C₄₈ alkyl and C₆-C₄₈ aryl, or a C₃-C₄₈ cycloalkyl group,

10

wherein each of R^{1a}, R^{1b}, R² to R⁴ and R⁸ to R²⁰ optionally, independently has bonded thereto at least one atom selected from the group consisting of an oxygen atom, a nitrogen atom, a sulfur atom, and a silicon atom, said at least one atom being present in a linkage other than a hydroxyl group, an epoxy group, an amino group, a silanol group and an alkoxy silane group,

20

and

25

each of t, u, v and x is independently
an integer of 0 or more, provided that
both t and u are not simultaneously 0, and
each of w, y, z and α is independently an
integer of 1 or more.

5

24. A method for producing the second-order modified polymer of any one of claims 20 to 23, comprising:

(1) providing a first-order modified polymer comprising:

(β) a base polymer which is unhydrogenated or at least partially hydrogenated and which is at least one member selected from the group consisting of the following polymers (β-1) to (β-3):

15 (β-1) a conjugated diene polymer comprising conjugated diene monomer units,

(β-2) a copolymer comprising conjugated diene monomer units and vinyl aromatic hydrocarbon monomer units, said copolymer having no or at least one polymer block (H) of said vinyl aromatic hydrocarbon monomer units, wherein said copolymer has a vinyl aromatic hydrocarbon block ratio of from 0 to less than 50 % by weight, said vinyl aromatic hydrocarbon block ratio being defined as the percent by weight of

25

the vinyl aromatic hydrocarbon monomer units contained in said at least one polymer block (H) of said vinyl aromatic hydrocarbon monomer units, based on the total weight of vinyl aromatic hydrocarbon monomer units contained in said copolymer as in the unhydrogenated state, and

5

(β-3) a vinyl aromatic hydrocarbon polymer comprising vinyl aromatic hydrocarbon monomer units, and

10

(γ) a functional group-containing first-order modifier group bonded to said base polymer (β), wherein said first-order modified polymer is produced by a process in which a base polymer having a living terminal is produced by a living anionic polymerization using an organolithium compound as a polymerization catalyst, and a functional group-containing first-order modifier is addition-bonded to said living terminal of said base polymer to obtain a first-order modified polymer, optionally followed by partial or complete hydrogenation of the obtained first-order modified polymer, and

15

20

25

(2) reacting a second-order modifier with said first-order modified polymer to thereby form (δ) a

functional group-containing modifier group, wherein
said second-order modifier has a functional group which
is reactive to said functional group of said first
-order modifier group (γ) of said first-order modified
5 polymer, and wherein said second-order modifier is used
in an amount of 0.3 to 10 moles, relative to one
equivalent of said functional group of said first-order
modifier group (γ) of said first-order modified polymer,
thereby obtaining a second-order modified polymer,
10 wherein said functional group-containing
first-order modifier group (γ) of said first-
order modified polymer comprises at least one
functional group represented by a formula se-
lected from the group consisting of the follow-
15 ing formulae (a) to (m):

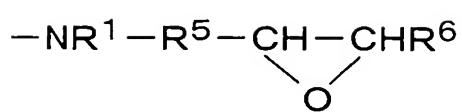
(a) $-NR^1-R^5-OH$

(b) $-N[R^5-OH]_2$

20 (c) $-NR^1-R^5-Si(OR^6)_3$

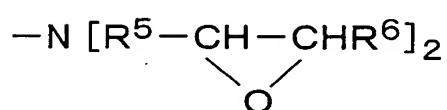
(d) $-N[R^5-Si(OR^6)_3]_2$

(e)



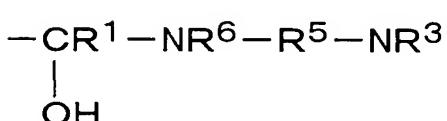
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(f)



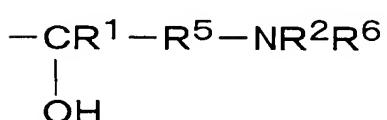
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(g)



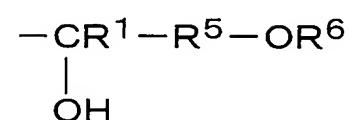
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(h)

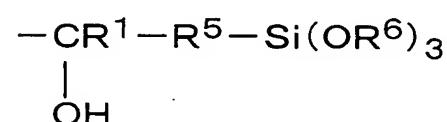


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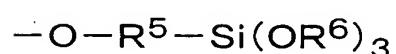
(i)



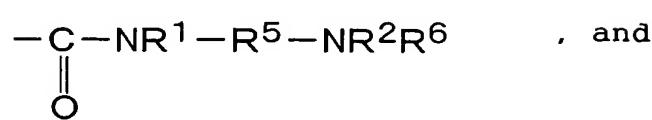
(j)

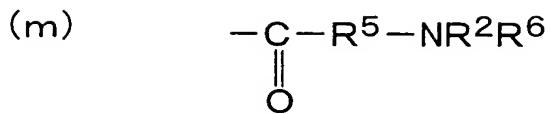


(k)



(l)





wherein, in the formulae (a) to (m):

5 N represents a nitrogen atom, Si represents a silicon atom, O represents an oxygen atom, C represents a carbon atom, and H represents a hydrogen atom,

10 each of R¹ to R⁴ independently represents a hydrogen atom or a C₁-C₂₄ hydrocarbon group which optionally has at least one functional group selected from the group consisting of a hydroxyl group, an epoxy group, an amino group, a silanol group and a C₁-C₂₄ alkoxy silane group,

15 each R⁵ independently represents a C₁-C₄₈ hydrocarbon group and optionally, independently has at least one functional group selected from the group consisting of a hydroxyl group, an epoxy group, an amino group, a silanol group and a C₁-C₂₄ alkoxy silane group,

20 each R⁶ independently represents a hydrogen atom or a C₁-C₈ alkyl group,

25 wherein each of R¹ to R⁵ optionally, in-

dependently has bonded thereto at least
one atom selected from the group consist-
ing of an oxygen atom, a nitrogen atom, a
sulfur atom and a silicon atom, said at
5 least one atom being present in a linkage
other than a hydroxyl group, an epoxy
group, an amino group, a silanol group and
an alkoxy silane group.

10 25. A filler-containing modified polymer composition
comprising:

100 parts by weight of (A-2) the second-order
modified polymer of any one of claims 20 to 23,
0.5 to 300 parts by weight of (B) a reinforcing
15 filler.

20 26. The filler-containing modified polymer composition
according to claim 25, wherein said reinforcing filler
(B) is at least one member selected from the group con-
sisting of a silica inorganic filler, a metal oxide, a
metal hydroxide and carbon.

25 27. A crosslinked, filler-containing modified polymer
composition obtained by subjecting the filler
-containing modified polymer composition of claim 25 or

26 to a crosslinking reaction in the presence of a vulcanizing agent.

28. A modified polymer composition comprising:

5 1 to 99 parts by weight, relative to 100 parts by weight of the total of components (A-2) and (D), of (A-2) the second-order modified polymer of any one of claims 20 to 23, and

10 99 to 1 part by weight, relative to 100 parts by weight of the total of components (A-2) and (D), of (D) at least one polymer selected from the group consisting of a thermoplastic resin other than said second-order modified polymer (A-2) and a rubbery polymer other than said second-order modified polymer (A-2).

15

29. The modified polymer composition according to claim 28, wherein said thermoplastic resin in component (D) comprises at least one member selected from the group consisting of a polyester resin, a polyamide resin, a polycarbonate resin, a polyurethane resin, a polyphenylene ether resin and a polyoxymethylene resin each of which contains at least one functional group selected from the group consisting of an acid anhydride group, a carboxyl group, a hydroxyl group, an epoxy group, an amino group, a silanol group and an alkoxy-

25

silane group.

30. A crosslinked, modified polymer composition obtained by subjecting the modified polymer composition of any one of claim 28 or 29 to melt-kneading in the presence of a vulcanizing agent.

5
31. An adhesive composition comprising:
100 parts by weight of (A-2) the second-order modified polymer of any one of claims 20 to 23, and
10 20 to 400 parts by weight of (E) a tackifier.

32. An asphalt composition comprising:
15 0.5 to 50 parts by weight of (A-2) the second-order modified polymer of any one of claims 20 to 23, and
and
100 parts by weight of (F) an asphalt.

33. A styrene resin composition obtained by subjecting 20 a raw material mixture to radical polymerization, said raw material mixture comprising:
25 2 to 30 parts by weight, relative to 100 parts by weight of the total of components (A-2) and (G), of (A-2) the second-order modified polymer of any one of claims 20 to 23, and

98 to 70 parts by weight, relative to 100 parts by weight of the total of components (A-2) and (G), of (G) a vinyl aromatic hydrocarbon monomer or a mixture of a vinyl aromatic hydrocarbon monomer and a comonomer co-polymerizable with said vinyl aromatic hydrocarbon monomer.

5 34. The styrene resin composition according to claim
33, wherein said raw material mixture further comprises
10 0.5 to 300 parts by weight, relative to 100 parts by
weight of component (A-2), of (B) a reinforcing filler.

15 35. The styrene resin composition according to claim
34, wherein said reinforcing filler (B) is at least one
member selected from the group consisting of a silica
inorganic filler, a metal oxide, a metal hydroxide and
carbon.

36. A filler-containing modified polymer composition comprising:

100 parts by weight of (A-3) a first-order modified polymer comprising:

5 (β) a base polymer which is unhydrogenated or at least partially hydrogenated and which is at least one member selected from the group consisting of the following polymers (β-1) to (β-3):

10 (β-1) a conjugated diene polymer comprising conjugated diene monomer units,

15 (β-2) a copolymer comprising conjugated diene monomer units and vinyl aromatic hydrocarbon monomer units, said copolymer having no or at least one polymer block (H) of said vinyl aromatic hydrocarbon monomer units, wherein said copolymer has a vinyl aromatic hydrocarbon block ratio of from 0 to less than 50 % by weight, said vinyl aromatic hydrocarbon block ratio being defined as the percent by weight of the vinyl aromatic hydrocarbon monomer units contained in said at least one polymer block (H) of said vinyl aromatic hydrocarbon monomer units, based on the total weight of vinyl aromatic hydrocarbon monomer units contained in said copolymer as in the unhydrogenated state,

and

(β-3) a vinyl aromatic hydrocarbon polymer comprising vinyl aromatic hydrocarbon monomer units, and

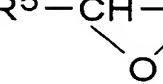
5 (γ) a functional group-containing first-order modifier group bonded to said base polymer (β), 0.5 to 300 parts by weight of (B) a reinforcing filler, and

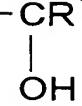
10 0.01 to 20 parts by weight of (C) a second-order modifier having a functional group which is reactive to said functional group of said first-order modifier group (γ) of said first-order modified polymer (A-3), wherein said second-order modifier (C) is at least one member selected from the group consisting of a functional monomer and a functional oligomer,

15 wherein said functional group-containing first-order modifier group (γ) of said first-order modified polymer (A-3) comprises at least one functional group represented by a formula selected from the group consisting of the following formulae (a) to (m):

(a) $-NR^1-R^5-OH$

25 (b) $-N[R^5-OH]_2$

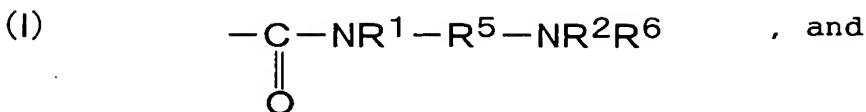
- (c) $-\text{NR}^1-\text{R}^5-\text{Si}(\text{OR}^6)_3$
- (d) $-\text{N}[\text{R}^5-\text{Si}(\text{OR}^6)_3]_2$
- (e) $-\text{NR}^1-\text{R}^5-\text{CH}-\text{CHR}^6$

- (f) $-\text{N}[\text{R}^5-\text{CH}-\text{CHR}^6]_2$

- (g) $-\text{CR}^1-\text{NR}^6-\text{R}^5-\text{NR}^3$

- (h) $-\text{CR}^1-\text{R}^5-\text{NR}^2\text{R}^6$

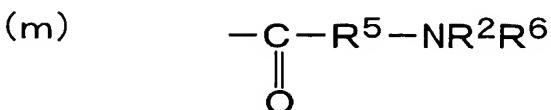
- (i) $-\text{CR}^1-\text{R}^5-\text{OR}^6$

- (j) $-\text{CR}^1-\text{R}^5-\text{Si}(\text{OR}^6)_3$

- (k) $-\text{O}-\text{R}^5-\text{Si}(\text{OR}^6)_3$



5



wherein, in the formulae (a) to (m):

10

N represents a nitrogen atom, Si represents a silicon atom, O represents an oxygen atom, C represents a carbon atom, and H represents a hydrogen atom,

15

each of R¹ to R⁴ independently represents a hydrogen atom or a C₁-C₂₄ hydrocarbon group which optionally has at least one functional group selected from the group consisting of a hydroxyl group, an epoxy group, an amino group, a silanol group and a C₁-C₂₄ alkoxy silane group,

20

each R⁵ independently represents a C₁-C₄₈ hydrocarbon group and optionally, independently has at least one functional group selected from the group consisting of a hydroxyl group, an epoxy group, an amino group, a silanol group and a C₁-C₂₄ alkoxy silane group,

25

each R⁶ independently represents a hydrogen atom or a C₁-C₈ alkyl group,
wherein each of R¹ to R⁵ optionally, independently has bonded thereto at least
5 one atom selected from the group consisting of an oxygen atom, a nitrogen atom, a sulfur atom and a silicon atom, said at least one atom being present in a linkage other than a hydroxyl group, an epoxy group, an amino group, a silanol group and
10 an alkoxy silane group.

37. The filler-containing modified polymer composition according to claim 36, wherein said reinforcing filler
15 (B) is at least one member selected from the group consisting of a silica inorganic filler, a metal oxide, a metal hydroxide and carbon.

38. A crosslinked, filler-containing modified polymer composition obtained by subjecting the filler
20 -containing modified polymer composition of claim 36 or 37 to a crosslinking reaction in the presence of a vulcanizing agent.

25 39. A modified polymer composition comprising:

1 to 99 parts by weight, relative to 100 parts by weight of the total of components (A-3) and (D), of (A-3) a first-order modified polymer comprising:

5 (β) a base polymer which is unhydrogenated or at least partially hydrogenated and which is at least one member selected from the group consisting of the following polymers (β-1) to (β-3):

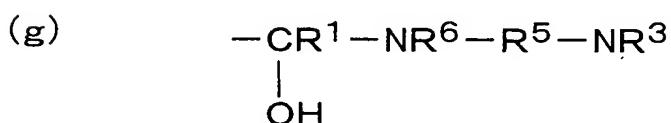
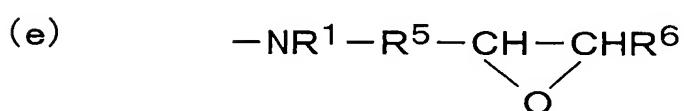
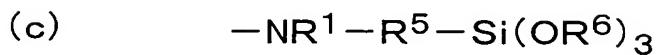
(β-1) a conjugated diene polymer comprising conjugated diene monomer units,

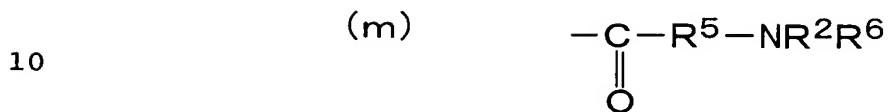
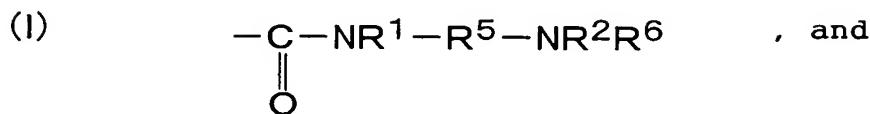
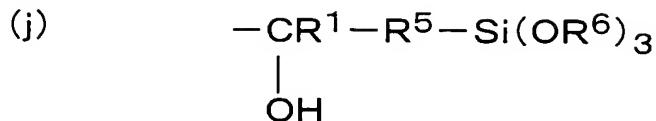
10 (β-2) a copolymer comprising conjugated diene monomer units and vinyl aromatic hydrocarbon monomer units, said copolymer having no or at least one polymer block (H) of said vinyl aromatic hydrocarbon monomer units, wherein said copolymer has a vinyl aromatic hydrocarbon block ratio of from 0 to less than 50 % by weight, said vinyl aromatic hydrocarbon block ratio being defined as the percent by weight of the vinyl aromatic hydrocarbon monomer units contained in said at least one polymer block (H) of said vinyl aromatic hydrocarbon monomer units, based on the total weight of vinyl aromatic hydrocarbon monomer units contained in said copolymer as in the unhydrogenated state,
15
20
25 and

(β -3) a vinyl aromatic hydrocarbon polymer comprising vinyl aromatic hydrocarbon monomer units, and

(γ) a functional group-containing first-order modifier group bonded to said base polymer (β),
5 99 to 1 part by weight, relative to 100 parts by weight of the total of components (A-3) and (D), of (D) at least one polymer selected from the group consisting of a thermoplastic resin other than said first-order
10 modified polymer (A-3) and a rubbery polymer other than said first-order modified polymer (A-3), and
0.01 to 20 parts by weight, relative to 100 parts by weight of the total of components (A-3) and (D), of
(C) a second-order modifier having a functional group
15 which is reactive to said functional group of said first-order modifier group (γ) of said first-order modified polymer (A-3), wherein said second-order modifier (C) is at least one member selected from the group consisting of a functional monomer and a functional
20 oligomer,
wherein said functional group-containing
first-order modifier group (γ) of said first
-order modified polymer (A-3) comprises at
least one functional group represented by a
25 formula selected from the group consisting of

the following formulae (a) to (m):





wherein, in the formulae (a) to (m):

N represents a nitrogen atom, Si represents a silicon atom, O represents an oxygen atom, C represents a carbon atom, and H represents a hydrogen atom,

each of R¹ to R⁴ independently represents a hydrogen atom or a C₁-C₂₄ hydrocarbon group which optionally has at least one functional group selected from the group consisting of a hydroxyl group, an epoxy group, an amino group, a silanol group and a C₁-C₂₄ alkoxysilane group,

20 each R⁵ independently represents a C₁-C₄₈ hydrocarbon group and optionally, inde-

pendently has at least one functional group selected from the group consisting of a hydroxyl group, an epoxy group, an amino group, a silanol group and a C₁-C₂₄ alkoxy silane group,

5

each R⁶ independently represents a hydrogen atom or a C₁-C₈ alkyl group, wherein each of R¹ to R⁵ optionally, independently has bonded thereto at least one atom selected from the group consisting of an oxygen atom, a nitrogen atom, a sulfur atom and a silicon atom, said at least one atom being present in a linkage other than a hydroxyl group, an epoxy group, an amino group, a silanol group and an alkoxy silane group.

10

15

40. The modified polymer composition according to claim 39, wherein said thermoplastic resin in component (D) comprises at least one member selected from the group consisting of a polyester resin, a polyamide resin, a polycarbonate resin, a polyurethane resin, a polyphenylene ether resin and a polyoxymethylene resin each of which contains at least one functional group selected from the group consisting of an acid anhydride

25

group, a carboxyl group, a hydroxyl group, an epoxy group, an amino group, a silanol group and an alkoxy-silane group.

5 41. A crosslinked, modified polymer composition obtained by subjecting the modified polymer composition of claim 39 or 40 to melt-kneading in the presence of a vulcanizing agent.

10 42. An adhesive composition comprising:
 100 parts by weight of (A-3) a first-order modified polymer comprising:

15 (β) a base polymer which is unhydrogenated or at least partially hydrogenated and which is at least one member selected from the group consisting of the following polymers (β-1) to (β-3):

 (β-1) a conjugated diene polymer comprising conjugated diene monomer units,

20 (β-2) a copolymer comprising conjugated diene monomer units and vinyl aromatic hydrocarbon monomer units, said copolymer having no or at least one polymer block (H) of said vinyl aromatic hydrocarbon monomer units, wherein said copolymer has a vinyl aromatic hydrocarbon block ratio of from 0 to less than 50 % by
25

weight, said vinyl aromatic hydrocarbon block ratio being defined as the percent by weight of the vinyl aromatic hydrocarbon monomer units contained in said at least one polymer block (H) of said vinyl aromatic hydrocarbon monomer units, based on the total weight of vinyl aromatic hydrocarbon monomer units contained in said copolymer as in the unhydrogenated state, and

10 (β-3) a vinyl aromatic hydrocarbon polymer comprising vinyl aromatic hydrocarbon monomer units, and

(γ) a functional group-containing first-order modifier group bonded to said base polymer (β), 15 20 to 400 parts by weight of (E) a tackifier, and 0.01 to 20 parts by weight of (C) a second-order modifier having a functional group which is reactive to said functional group of said first-order modifier group (γ) of said first-order modified polymer (A-3), 20 wherein said second-order modifier (C) is at least one member selected from the group consisting of a functional monomer and a functional oligomer,

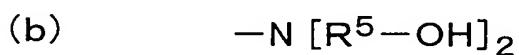
25 wherein said functional group-containing first-order modifier group (γ) of said first-order modified polymer (A-3) comprises at least

one functional group represented by a formula selected from the group consisting of the following formulae (a) to (m):

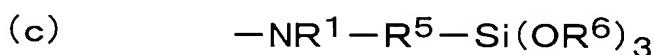
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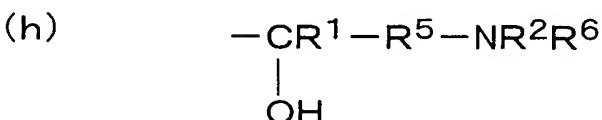
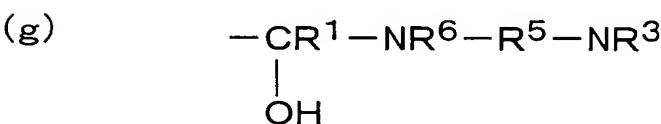
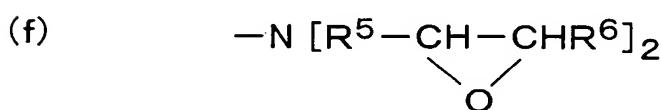
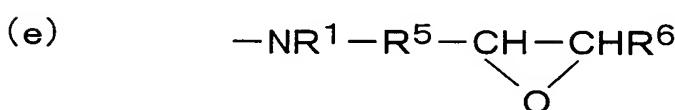
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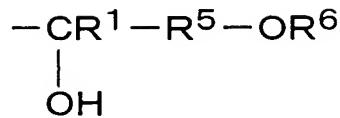
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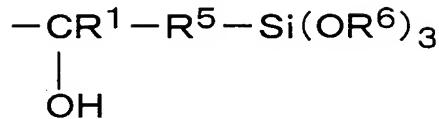


(i)



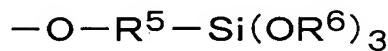
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(j)

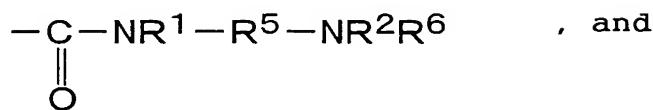


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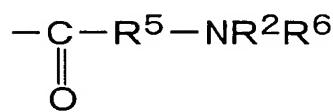
(k)



(l)



(m)



15

wherein, in the formulae (a) to (m):

N represents a nitrogen atom, Si represents a silicon atom, O represents an oxygen atom, C represents a carbon atom, and H represents a hydrogen atom,

20

each of R¹ to R⁴ independently represents a hydrogen atom or a C₁-C₂₄ hydrocarbon group which optionally has at least one functional group selected from the group consisting of a hydroxyl group, an epoxy group, an amino group, a silanol

25

group and a C₁-C₂₄ alkoxy silane group,

each R⁵ independently represents a C₁-C₄₈ hydrocarbon group and optionally, independently has at least one functional group selected from the group consisting of a hydroxyl group, an epoxy group, an amino group, a silanol group and a C₁-C₂₄ alkoxy silane group,

5

each R⁶ independently represents a hydrogen atom or a C₁-C₈ alkyl group,

10

wherein each of R¹ to R⁵ optionally, independently has bonded thereto at least one atom selected from the group consisting of an oxygen atom, a nitrogen atom, a sulfur atom and a silicon atom, said at least one atom being present in a linkage other than a hydroxyl group, an epoxy group, an amino group, a silanol group and an alkoxy silane group.

15

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43. An asphalt composition comprising:

0.5 to 50 parts by weight of (A-3) a first-order modified polymer comprising:

25

(β) a base polymer which is unhydrogenated or at least partially hydrogenated and which is at

least one member selected from the group consisting of the following polymers (β -1) to (β -3):

(β-1) a conjugated diene polymer comprising conjugated diene monomer units,

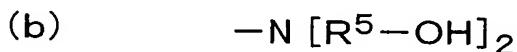
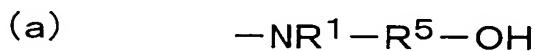
(β-3) a vinyl aromatic hydrocarbon polymer comprising vinyl aromatic hydrocarbon monomer units, and

(γ) a functional group-containing first-order modifier group bonded to said base polymer (β),

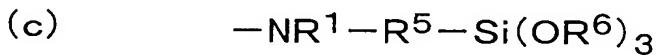
100 parts by weight of (F) an asphalt, and
0.01 to 20 parts by weight of (C) a second-order
modifier having a functional group which is reactive to
said functional group of said first-order modifier
group (γ) of said first-order modified polymer (A-3),
wherein said second-order modifier (C) is at least one
member selected from the group consisting of a func-
tional monomer and a functional oligomer,

5 wherein said functional group-containing
10 first-order modifier group (γ) of said first
 -order modified polymer (A-3) comprises at
 least one functional group represented by a
 formula selected from the group consisting of
 the following formulae (a) to (m):

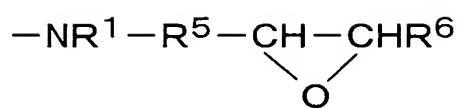
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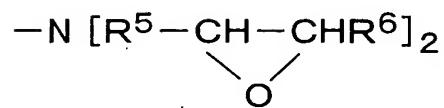
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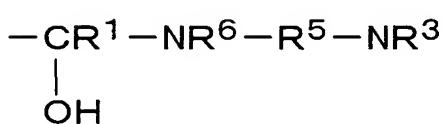
(e)



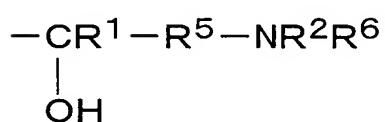
(f)



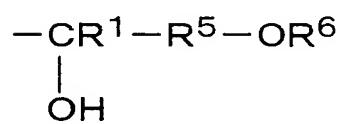
(g)



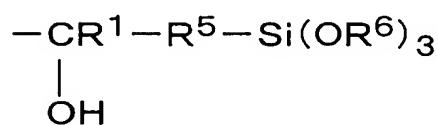
(h)



(i)



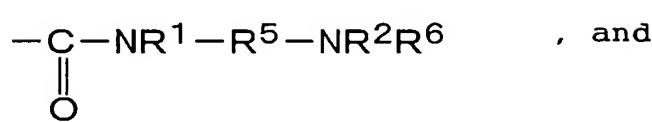
(j)

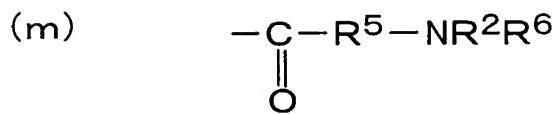


(k)



(l)





wherein, in the formulae (a) to (m):

- 5 N represents a nitrogen atom, Si represents a silicon atom, O represents an oxygen atom, C represents a carbon atom, and H represents a hydrogen atom,
- 10 each of R¹ to R⁴ independently represents a hydrogen atom or a C₁-C₂₄ hydrocarbon group which optionally has at least one functional group selected from the group consisting of a hydroxyl group, an epoxy group, an amino group, a silanol group and a C₁-C₂₄ alkoxy silane group,
- 15 each R⁵ independently represents a C₁-C₄₈ hydrocarbon group and optionally, independently has at least one functional group selected from the group consisting of a hydroxyl group, an epoxy group, an amino group, a silanol group and a C₁-C₂₄ alkoxy silane group,
- 20 each R⁶ independently represents a hydrogen atom or a C₁-C₈ alkyl group,
- 25 wherein each of R¹ to R⁵ optionally, in-

dependently has bonded thereto at least one atom selected from the group consisting of an oxygen atom, a nitrogen atom, a sulfur atom and a silicon atom, said at least one atom being present in a linkage other than a hydroxyl group, an epoxy group, an amino group, a silanol group and an alkoxy silane group.

10 44. A styrene resin composition obtained by subjecting a raw material mixture to radical polymerization, said raw material mixture comprising:

15 2 to 30 parts by weight, relative to 100 parts by weight of the total of components (A-3) and (G), of (A-3) a first-order modified polymer comprising:

(β) a base polymer which is unhydrogenated or at least partially hydrogenated and which is at least one member selected from the group consisting of the following polymers (β-1) to (β-3):

20 (β-1) a conjugated diene polymer comprising conjugated diene monomer units,

(β-2) a copolymer comprising conjugated diene monomer units and vinyl aromatic hydrocarbon monomer units, said copolymer having no or at least one polymer block (H) of said vinyl

aromatic hydrocarbon monomer units, wherein
said copolymer has a vinyl aromatic hydrocarbon
block ratio of from 0 to less than 50 % by
weight, said vinyl aromatic hydrocarbon block
ratio being defined as the percent by weight of
the vinyl aromatic hydrocarbon monomer units
contained in said at least one polymer block
(H) of said vinyl aromatic hydrocarbon monomer
units, based on the total weight of vinyl aro-
matic hydrocarbon monomer units contained in
said copolymer as in the unhydrogenated state,
and

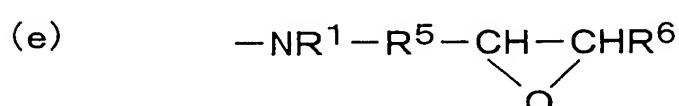
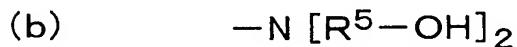
15 (β-3) a vinyl aromatic hydrocarbon polymer
comprising vinyl aromatic hydrocarbon monomer
units, and

15 (γ) a functional group-containing first-order
modifier group bonded to said base polymer (β),
98 to 70 parts by weight, relative to 100 parts by
weight of the total of components (A-3) and (G), of (G)
20 a vinyl aromatic hydrocarbon monomer or a mixture of a
vinyl aromatic hydrocarbon monomer and a comonomer co-
polymerizable with said vinyl aromatic hydrocarbon
monomer, and

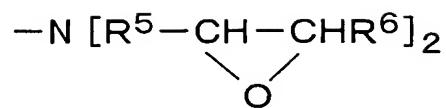
25 0.01 to 20 parts by weight, relative to 100 parts
by weight of the total of components (A-3) and (G), of

(C) a second-order modifier having a functional group which is reactive to said functional group of said first-order modifier group (γ) of said first-order modified polymer (A-3), wherein said second-order modifier (C) is at least one member selected from the group consisting of a functional monomer and a functional oligomer,

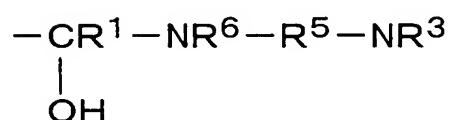
wherein said functional group-containing first-order modifier group (γ) of said first-order modified polymer (A-3) comprises at least one functional group represented by a formula selected from the group consisting of the following formulae (a) to (m):



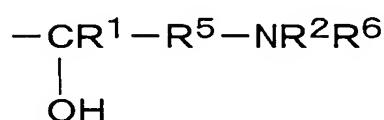
(f)



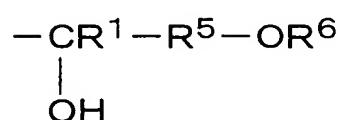
5 (g)



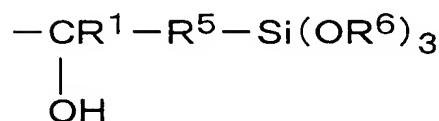
(h)



10 (i)

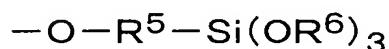


(j)

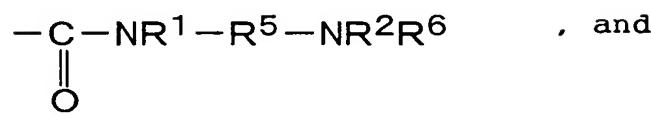


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(k)

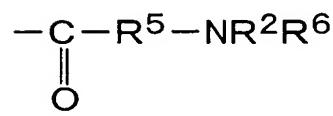


(l)



20

(m)



wherein, in the formulae (a) to (m):

25

N represents a nitrogen atom, Si repre-

sents a silicon atom, O represents an oxygen atom, C represents a carbon atom, and H represents a hydrogen atom,

each of R¹ to R⁴ independently represents a hydrogen atom or a C₁-C₂₄ hydrocarbon group which optionally has at least one functional group selected from the group consisting of a hydroxyl group, an epoxy group, an amino group, a silanol group and a C₁-C₂₄ alkoxy silane group,

each R⁵ independently represents a C₁-C₄₈ hydrocarbon group and optionally, independently has at least one functional group selected from the group consisting of a hydroxyl group, an epoxy group, an amino group, a silanol group and a C₁-C₂₄ alkoxy silane group,

each R⁶ independently represents a hydrogen atom or a C₁-C₈ alkyl group,

wherein each of R¹ to R⁵ optionally, independently has bonded thereto at least one atom selected from the group consisting of an oxygen atom, a nitrogen atom, a sulfur atom and a silicon atom, said at least one atom being present in a linkage

other than a hydroxyl group, an epoxy group, an amino group, a silanol group and an alkoxy silane group.

5 45. The styrene resin composition according to claim 44, wherein said raw material mixture further comprises 0.5 to 300 parts by weight, relative to 100 parts by weight of component (A-3), of (B) a reinforcing filler.

10 46. The styrene resin composition according to claim 45, wherein said reinforcing filler (B) is at least one member selected from the group consisting of a silica inorganic filler, a metal oxide, a metal hydroxide and carbon.